

Improved anti-dermatophytic preparation and use thereof

Field of invention

The present invention provides an improved preparation based on the synergistic action of garlic extract and essential oil of *M. spicata* var. Ganga or cinnamon oil against dermatophytic fungus. More particularly, the present invention relates to the synergistic enhancement of activity of a combination by menthyl acetate or Geraniol. The invention also provides a method of preparation of the synergistic combination and the shelf life observed to be more than one year. The cream based preparation is a potent anti-dermatophytic as described and illustrated by *in vitro* and *in vivo* evaluations.

Back Ground of the invention

Garlic, *Allium sativum* L (*Liliaceae*) has been used traditionally to treat a number of infectious diseases including those caused by bacteria, fungi, protozoa and viruses (Nor best. D. Weber et al. 1992, *Planta Medica* 58:418). Beside these, it has also been used for broad range of therapeutic properties including anti-inflammatory, anti-diabetic, anti-atherogenic, anti-coagulant anti-cancer and neurotropic. (M. Colic. et al *Phytomedicine* 9: 117-124. 2002).

A number of reports are available on *in vitro* and *in vivo* efficacy of garlic oil, juice, extract (water or solvent) or lyophilised water extract against plant and human pathogens causing fungal and bacterial infections. The activity of garlic against dermatophytosis *i.e.* the superficial infections of skin or keratinised tissue of man and animals can be very well visualised from the reports of Venugopal and Venugopal 1995 and Prasad et al 1982, 1983 and 1987. Venugopal, 1995 [*International Journal of Dermatology* 34(4) 278-279] reported the activity of garlic extracts against 88 clinical isolates of dermatophytes by agar dilution technique, which includes *Microsporum cannis*, *M. audouinii* *Trichophyton rubrum* *T. mentagraphytes*, *T. violaccum*, *T. simii*, *T. verrucosum* *T. erinacci* and *Epidermophytn floccosum*. while Prasad et al, 1982, 1983 reported clinical findings of garlic extract against dermatophytes in animals and human beings, [*Indian Journal of Medical research* 1982 465-467, *Indian Veterinary Medical journal* 1983 7 (3) 161-163 and *Poultry science* 1981 60 (3) 541-545 *Indian Veterinary Medical journal* 1987 11 (2) 108-110] Besides these reports, many

workers have described effect of garlic extract against isolated or experimental infections, those include the work of Sharma S.R. et al 1994 [International journal of Animal sciences 9 (2) 239-240.] Sharma M.C. [Indian Veterinary Journal 1990 67 (3) 269-271,] Thakur DK et al [Indian journal of Animal-Health 1987 26 (1) 31-34 & Indian veterinary journal 1983 60 (10) 799-801] Upadhyay.MP et al 1980 [Journal of general & applied microbiology 1980 26 6, 421-424.] Rajora V.S. Indian Veterinary Journal 1982. 59 (10) 815-817.

All the above reports and many others have utilized garlic extract (solvent or water), juice, or oil for the *in vitro* or *in vivo* evaluation of the infections caused by various species of dermatophytes viz. *Trichophyton* *Microsporum* *Epidermophyton* and yeast like fungi of genera *Candida*, *Cryptococcus*, *Rhodotorula*. *Torulopsis trichosporon*. It is also evident from the above reports that Garlic can be utilized in broad spectrum antifungal preparation for topical application but the instability of the activity and the disagreeable smell are two main constraints in its formulations as the activity of garlic juice / extract degrade & finally lost on storage and higher concentration produces disagreeable smell. The loss in activity due to storage may be attributed to the fact that garlic possesses unstable compounds. Up to now more than 200 different biologically active substances has been isolated from garlic, among them organosulphur compounds such as allicin azoenes, diallyltrisulfide (DATS) or s-allylcystein, are considered the most important biologically active compound found in crushed or homogenised garlic [Colic M et. al. Phytomedicine 2000 9 117 -124]. It is unstable in the presence of heat or organic solvent and forms a variety of degraded compounds. Allicin is not present in garlic but is rapidly procured when its precursor alliin is cleaved by alliinase upon crushing or mincing of garlic because allin and alliinase are very stable when dry. Garlic powders have potential to preserve allin without degradation the allicin. However some powder preparations do release allicin upon aqueous contact which vary depending upon the source.

Due to pronounced antibacterial and antifungal properties garlic have been used as insecticides to control plant diseases such as army worms, aphids and Colorado beetles. Anderson et al, U.S. Pat No. 5,733,552 has utilised garlic extract & water to repel mosquito.

Hsu, et al, 2001, US. Patent 6, 231, 685 entitle " Natural pesticide" has utilized garlic oil or extracts in combination with essential oils and found an improvement in insecticidal and fungicidal activity. They have utilized various combinations to control insects and fungal infection on plants. The invention also describes a synergistic effect of garlic oil or extract combined with essential oils, resulting in improved insecticidal, fungicidal activities. The essential oils described in this patent are cotton seed oil, soyabean oil, cinnamon oil corn oil, cedar oil, castor oil, clove oil, geranium oil, lemon grass oil, linseed oil, mint oil, sesame oil, thyme oil, rosemary oil, anise oil, basil oil, camphor oil, citronella oil, Eucalyptus oil, Fennel oil, Ginger oil, grapefruit oil, lemon oil, mandarin oil, orange oil, pine needle oil, pepper oil, rose oil, tangerine oil, tea tree oil, tee seed oil, mineral and fish oil.

But till today no report is available on synergism of the garlic extract with plant essential oils or constituents for stable anti-dermatophytic activity. The invention is novel as the formulation uses the essential oil of the plant *Mentha spicata* var Ganga. This improved formulation from plant source is highly potent in *in vitro* and *in vivo* evaluations. This improved preparation against dermatophytic fungus is novel due to better synergism in activity, better stability and shelf life and reduced smell of garlic which is masked by the other ingredients.

Objects of the invention

The main object of the present invention is to develop a herbal formulations active against broad spectrum of dermatophytic fungi.

Another object of the invention is to provide a formulation useful as a topical cream, which smoothens the skin and allows slow absorption of the contents, there by causing effective action, which completely eliminates the infection caused by dermatophytic fungi.

Yet another object of the invention is to provide an antifungal formulation containing garlic extract (*Allium sativum*) where the smell of garlic is masked and the product bears pleasant and agreeable smell.

Yet another object of the invention is to provide an antifungal formulation having combination of garlic extract, essential oil and certain constituents of essential oil to amplify the synergistic effects.

Yet another object of the invention is to provide an antifungal formulation which is commercially viable and cheaper as compared to other creams available in the market.

Yet another object of the invention is to provide an anti-dermatophytic formulation which is totally natural and has not any preservative.

Yet another object of the invention is to provide a garlic based anti-dermatophytic cream which has long shelf life period.

Summary of the invention

The invention provides a novel formulation based on the synergistic action of garlic extract and essential oil of *M. spicata* var Ganga or cinnamon oil alone or in combination with both which may further be enhanced by menthyl acetate or Geraniol. Further the invention provides a method of preparation of the synergistic combination. The shelf life of the said invention was observed to be more than one year. The oil of *M. spicata* var Ganga act as preservative for the cream. The cream is a potent anti-dermatophytic as described and illustrated and evaluated in human volunteers.

Accordingly, the present invention provides a novel synergistic antifungal formulation active against dermatophytic fungi comprising a garlic extract in propylene glycol, essential oil of *M. spicata* Var Ganga or cinnamon oil alone or in combination along with menthyl acetate or geraniol in suitable base.

In one embodiment of the invention, the base is prepared by mixing stearyl alcohol, cetyl alcohol and propylene glycol at 70-75°C over water bath and cooling down the preparation with constant stirring up to ambient temperature and finally curing for 48 hours in covered beaker with occasional mixing the product.

In another embodiment of the invention, the garlic extract is present in an amount of 1-3% and the essential oil of *Mentha spicata* var Ganga or cinnamon oil alone or in

combination is present in an amount of 2%-5% and wherein constituents of essential oil like menthyl acetate or geraniol is added to the base at temperature 30-35°C.

In another embodiment of the invention, the garlic extract in propylene glycol is present in a concentration in the range of 1% - 2.5%.

In yet another embodiment of the invention, the essential oil of *M. spicata* var Ganga is present in a concentration in the range of 2% - 5%.

In a further embodiment of the invention, the cinnamon essential oil is present in a concentration in the range of 0.01% - 0.8%

In yet another embodiment of the invention, the menthyl acetate is present in a concentration in the range of 0.3%-1.2%

In a further embodiment of the invention, the concentration of geraniol is about 1%.

In yet another embodiment of the invention, the dermatophytic fungi are selected from the group consisting of *Candida*, *Trichophyton*, *Microsporum* and *Epidermophyton*.

In another embodiment of the invention, the shelf life of the formulation is more than one year.

The synergistic/enhancing activity of garlic extract on essential oils as the minimum inhibitory concentrations of the essential oils were decreased to several folds in presence of the garlic extract (Propylene glycol) indicating the enhancing and synergistic activity of garlic extract on activity of essential oils.

In yet another embodiment of the invention, the synergistic antifungal preparation of the invention active against dermatophytic fungi comprises of garlic extract in propylene glycol, essential oil of *M. spicata* Var Ganga or cinnamon oil alone or in combination, along with menthyl acetate or geraniol in suitable base wherein the improved formulation act by inhibiting the ergosterol biosynthesis.

In yet another embodiment of the invention, the formulation is active against dermatophytic fungi by making the sterol non-available for cell membrane biosynthesis.

In a further embodiment of the invention, the antifungal formulation is active against dermatophytic fungi, wherein the fungi may or may not be sensitive to synthetic antifungal compounds selected from the group consisting of azoles and polyenes.

In another embodiment of the invention, the antifungal formulation is active against dermatophytic fungi and the antifungal formulation shows clearing of the fungal culture indicating clear lysis.

The present invention also relates to a method for the treatment of dermatophytic fungi comprising administering to a subject infected with the dermatophytic fungi an effective amount of a antifungal preparation comprising a garlic extract in propylene glycol, essential oil of *M. spicata* Var Ganga or cinnamon oil alone or in combination along with menthyl acetate or geraniol in suitable base.

In one embodiment of the invention, the base is prepared by mixing stearyl alcohol, cetyl alcohol and propylene glycol at 70-75°C over water bath and cooling down the preparation with constant stirring up to ambient temperature and finally curing for 48 hours in covered beaker with occasional mixing the product.

In another embodiment of the invention, the garlic extract is present in an amount of 1-3% and the essential oil of *Mentha spicata* var Ganga or cinnamon oil alone or in combination is present in an amount of 2%-5% and wherein constituents of essential oil like menthyl acetate or geraniol is added to the base at temperature 30-35°C.

In another embodiment of the invention, the garlic extract in propylene glycol is present in a concentration in the range of 1% - 2.5%.

In yet another embodiment of the invention, the essential oil of *M. spicata* var Ganga is present in a concentration in the range of 2% - 5%.

In a further embodiment of the invention, the cinnamon essential oil is present in a concentration in the range of 0.01% - 0.8%

In yet another embodiment of the invention, the menthyl acetate is present in a concentration in the range of 0.3%-1.2%

In a further embodiment of the invention, the concentration of geraniol is about 1%.

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In a further embodiment of the invention, the antifungal formulation is active against dermatophytic fungi wherein the fungi may or may not be sensitive to synthetic antifungal compounds selected from the group consisting of azoles and polyenes.

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Detailed description

The improved formulation was carefully planned, experimented and evaluated *in vitro* and *in vivo* as described and illustrated below.

Example 1:

In our experiments we found that all essential oil do not produce synergistic effects with dermatophytes as in case of plant pathogens described in US Patent 6231685. Following tables presents the results of evaluation of antifungal activities of water or solvent extracts of garlic in combinations with the essential oils. As investigation contain solvent extract (propylene glycol) was found to more potent than the water extract and hence in subsequent experiments solvent extract was used for measuring the activities. The combinations of essential oils and garlic extracts were made according to their MICs (minimum inhibitory combinations). The table clearly reveal that the essential oil of *Eucalyptus* hybrid, *E.citriodora*, *Mentha citrata*, *M. arvensis*, *Ocimum basilicum* (French basil), *Ocimum sanctum*, *Cymbopogon winterianus*, *Trachyspermum ammi* (Thyme oil), *Cumin cyminum*, *Anethum soya*, Cedar wood oil, sesame oil have produced the antagonistic effects in case of *Candida albicans* and *Trichophyton rubrum* when evaluated with garlic extract. But only

selected oils viz. *Mentha spicata* van. Ganga, Cinnamon oil produced the synergistic effect when used together or separately with garlic extract. The activity increased to several folds when these combinations were added to constituent of essential oil like menthyl acetate. The additions of these isolates not only enhanced the activity but also mask the smell of garlic to generate a pleasant smell. The broth assay was carried out following the NCCLS documents published by National Committee for Clinical and Laboratory Standards (USA) and disc diffusion assay according to Bauer et al (Bauer et al, 1996, American Journal of Clinical Pathology, 45:493-496) .

Table 1: Disc diffusion assay of garlic extract /essential oils alone and in combination.
(Net zone of inhibition in mm)

Essential oils	<i>Trichophyton rubrum</i>	<i>Trichophyton rubrum</i>	<i>Candida albicans</i> (MTCC1637)	<i>Candida albicans</i> (MTCC1637)
	Garlic extracts used alone 7mm	Garlic extracts in combination with essential oil	Garlic extracts used alone 15mm	Garlic extracts in combination with essential oil
	Essential oil used alone		Essential oil used alone	
<i>Eucalyptus globulus</i>	3	10	5	20
<i>Mentha citrata</i>	3	5	8	21
<i>Ocimum sanctum</i>	15	10	17	25
French basil oil	6	7	11	17
Thyme oil	32	34	48	45
Clocimum	21	17	20	20
Citronella oil	15	17	14	20
Fennel oil	5	15	10	20
Rosemary oil	4	14	5	10
Cumin oil	15	17	25	25
Cedar wood oil	-	5	-	10
Sesame oil	-	6	-	5

Table 2: Broth assay of garlic extract in combination with essential oils (using two fold dilution method) against *Candida albicans* MTCC1637)

Essential oils	MIC of Essential oils	Concentration of garlic extract used in combination with oils	Reduction in the MIC of Essential oils	Fold enhancement on the basis of Reduction in the MIC of Essential oils	Type of Interaction	FIC Value
Garlic extract	1/800					
Eucalyptus globulus	1/400	1/1600	1/800	2	1.0	Indifference
		1/3200	1/800	2	0.75	Additive
Eucalyptus hybrid	1/1600	1/1600	1/1600	1	1.5	Antagonistic
		1/3200	1/1600	1	0.75	Additive
Eucalyptus citridora	1/1600	1/1600	1/1600	1	1.5	Antagonistic
		1/3200	>1/1600	-	>1.5	Antagonistic
Mentha citrata	1/800	1/1600	>1/1600	-	>1.5	Antagonistic
		1/3200	>1/1600	-	>1.5	Antagonistic
Mentha arvensis	1/1600	1/1600	1/1600	1	1.5	Antagonistic
		1/3200	>1/1600	-	>1.5	Antagonistic
Rosemary oil	1/400	1/1600	1/1600	4	0.75	Additive
		1/3200	1/800	2	0.75	Additive
Ocimum sanctum oil	1/800	1/1600	1/1600	2	1.0	Indifference
		1/3200	1/1600	2	0.75	Additive
French basil oil	1/1600	1/1600	>1/1600	-	>1.0	Antagonistic
		1/3200	>1/1600	-	>1.0	Antagonistic
Clocimum	1/1600	1/1600	1/3200	2	1.0	Indifference
Citronella oil	1/1600	1/1600	1/1600	1	1.5	Antagonistic
		1/3200	>1/1600	-	>1.0	Antagonistic
Thyme oil	1/6400	1/1600	1/6400	1	1.5	Antagonistic

		1/3200	1/6400	1	1.25	Antagonistic
Cumin oil	1/800	1/1600	1/800	1	1.5	Antagonistic
		1/3200	>1/800	-	>1.5	Antagonistic
Fennel oil	1/400	1/1600	>1/800	-	>1.5	Antagonistic
		1/3200	>1/800	-	>1.5	Antagonistic

Table 3: Broth assay of garlic extract in combination with one essential oils (using two fold dilution method) against *Candida albicans*

Essential oil/Plant compound/extract	MIC of essential oil/extract	Concentration of garlic extract used in combination with oil	Reduction in the MIC of oil	Fold enhancement on the basis of Reduction in the MIC of oil in combination	Type of Interaction	FIC value
Garlic extract	1/800					
Menthyl acetate	1/800	1/1600	1/1600	2	Indifference	1.0
		1/3200	1/1600	2	Additive	0.75
		1/6400	1/1600	2	Additive	0.625
Cinnamon oil	1/12800	1/1600	1/25600	2	Indifference	1.0
		1/3200	1/12800	1	Antagonistic	>1.0
		1/6400	1/12800	1	Antagonistic	>1.0
<i>Mentha spicata</i>	1/800	1/1600	1/1600	2	Indifference	1.0
		1/3200	1/1600	2	Additive	0.75
		1/6400	>1/800	-	Antagonistic	>1.0

Table 4: Broth assay of garlic extract in combination with two essential oils/component (using two fold dilution method) against *Candida albicans*

Two oils used in combination	Concentration of	Reduction in	Fold enhancement on	Type of	FIC Value
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and their Concentration used	garlic extract used in combination with oils	the MIC of 1 st oil (used in series)	the basis of Reduction in the MIC of oil which is serially diluted (1)	Interaction	
Cinnamon (1/12800) + <i>Mentha spicata</i> (Ganga) (1/1600)	1/1600	1/102400	8	Additive	0.625
Cinnamon (1/12800) + <i>Mentha spicata</i> (Ganga) (1/3200)	1/3200	1/25600	2	Additive	0.75
Cinnamon (1/12800) + <i>Mentha spicata</i> (Ganga) (1/6400)	1/1600	1/25600	2	Indifference	1.0
Cinnamon (1/12800) + <i>Mentha spicata</i> (Ganga) (1/1600)	1/6400	1/102400	8	Synergistic	0.25
Cinnamon (1/12800) + <i>Mentha spicata</i> (Ganga) (1/3200)	1/6400	1/25600	2	Additive	0.625
<i>Mentha spicata</i> (Ganga) (1/1600) + Cinnamon (1/25600)	1/3200	1/6400	8	Synergistic	0.25
<i>Mentha spicata</i> (Ganga) (1/1600) + Cinnamon (1/25600)	1/6400	1/3200	4	Synergistic	0.375
Menthyl acetate(1/1600)+ Cinnamon (1/25600)	1/3200	1/6400	8	Synergistic	0.375
Menthyl acetate (1/1600)+ Cinnamon (1/51200)	1/3200	1/6400	8	Synergistic	0.375

Development and Testing of Formulation

In an effort to prepare a garlic based cream for topical application against superficial fungal infection of keratinised tissue of skin, selection of proper carrier solvent for garlic extraction was made as follows.

Preparation of extract: - 50 gm of raw garlic without removing the inner skin was properly homogenised in mortar & pestle along with 50 ml of

- A. Distilled water
- B. Vegetable oil (linseed oil)
- C. Ethyl alcohol
- D. Propylene glycol
- E. Liquid paraffin

After properly homogenisation the material was filtered after 1 hrs by double layer of muslin cloth and filtrate was used as garlic extract. The supernatant liquid was used as extract. The extracts in oil and liquid paraffin have two layers with emulsion at the junction of the water layer. The emulsion was rejected and the volume of the remaining supernatant was made up of to 50 ml by adding appropriate amount of respective solvent. The solution was utilized for testing of antifungal activity as mother solution. The antifungal activity was tested [Bauer et al,1996, Journal of Clinical Pathology, 45:493-496], which revealed that the garlic extracted in propylene glycol, is the best solvent for antifungal activity.

It was further observed that the activity is lost by keeping the homogenised material more than 24 hrs at room temperature (30-35°). The propylene glycol extract when tested after 15 days of storage at room temperature no activity was recorded. Similarly deterioration of activity was recorded for the extract when stored at 5°C for 15 days. The pH of garlic with water was recorded to be 5.8 while the propylene glycol extract (50g garlic+50 g propylene glycol) was 6.17. The activity of garlic extract in propylene glycol was slightly increased in acidic pH 4.5 by adding citric acid. When the propylene glycol extract was warmed up to 40° to 60° for 30 minute in water bath the activity decreased.

Table 5:

	<i>Candida albican</i> (MTCC1637)	<i>Trichophyton rubrum</i>
1. Garlic juice	-	-
2. Garlic extract in propylene glycol	15	7
3. Garlic juice + citric acid pH 4.5	3	3
4. Garlic juice propylene glycol at 40°	2	2
5. Garlic juice propylene glycol at 60°	1	2

The combination of cinnamon oil with menthyl acetate (isolated from the essential oil of *M. arvensis*) and cinnamon oil with the essential oil of *M. spicata* variety Ganga were found to be having synergistic effect on antifungal activity when used along with garlic extract (propylene glycol). In all the cases the MIC of both garlic extract and essential oils have been drastically reduced enhancing the activity of garlic and also masking the smell. On the basis of above results the following combinations were prepared.

Preparations

Ingredients Stearyl alcohol – 4 gm

Cetyl alcohol 2 gm

White petrolatum - 4 gm

Oil, constituent and extract of garlic as per quantity provided below.

Propylene glycol remaining amount upto 20 g total weight.

Product	Concentration of garlic extract in 20 g cream	Concentration of oils and/or constituent ml per 20 gm total weight	
Cream No 1	0.25 g	<i>M. spicata</i> Var Ganga	0.4
Cream No 2	0.5 g	Menthyl acetate	0.04
Cream No 3	0.5 g	<i>M. spicata</i> Var Ganga	0.04

Cream No 4	No extract	Menthyl acetate Cinnamon	.02 .002
Cream No 5	0.5 g	Menthyl acetate Cinnamon	0.02 0.002
Cream No 7	0.6 g	Geraniol	0.2
Cream No 8	No extract	Geraniol	0.2

Method for preparing cream –

Specified quantities of stearyl alcohol and cetyl alcohol was melted along with white petrolatum and propylene glycol in a water bath (70-75°C) with constant stirring. The mixture was cooled down to 35-40°C and required amount of extract followed by essential oil were added with thorough mixing for homogenisation. The cream was left for curing with occasional mixing at periodic intervals 3 to 4 times. The cream thus prepared were transferred to plastic covered containers till the antifungal evaluation were made.

Example 2

Table 6: Antifungal evaluation by hole diffusion method

Product	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i>	<i>Epidermophyton floccosum</i>
1	4	14	69	38
2	-	2	10	8
3	-	2	22	18
4	-	-	-	-
5	-	-	12	14
6	-	-	10	13
7	-	-	10	18

The combinations utilised in cream No 1 is promising as per the result and this combination was taken for further improvement.

Example 3

Two creams were prepared for further improvement in cream 1

1 A. The concentrations of oil and garlic extract were doubled.

1 B. The concentration of oil was doubled

To maintain the cream to 20 gm the concentration of propylene glycol was changed accordingly.

Method of preparation – Ingredients for 20 gm. Cream

Stearyl alcohol 4g

Cetyl alcohol 2g

Petrolatum white 4g

Propylene glycol remaining amount to make the cream to 20g

Product	Conc. of garlic extract (g /20 g).	Essential oil of <i>M. spicata</i> Var Ganga (ml in 20 g)
Cream 1 (A)	0.5 gm extract	0.8 ml oil
Cream 1(B)	0.25 gm extract	0.8 ml oil

Antifungal activity of cream 1 (A) ad 1 (B) & comparison with mixture of extract and oil (Net zone of inhibition in mm)

Product	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i>	<i>Epidermophyt on floccosum</i>
Cream 1 (A)	10	34	CL	53
Cream 1 (B)	7	35	CL	58
<i>Mentha spicata</i> var. Ganga Oil + garlic extract	13	34	CL	CL

CL. complete lysis after 5-7 days

For further improvement more combination of garlic extract and *M. spicata* var. Ganga was tried.

Example 4:

All Ingredients and the procedure adapted were same as described in example 3 and only the concentration of active ingredients were changed as follows.

Product	Garlic extract (g/20g).	Oil <i>M. spicata</i> var Ganga ml/20g
Cream 8 (1)	0.6	1 .0
Cream 8 (2)	0.3	0.5

Anti fungal evaluations by hole diffusion method (Net zone of inhibition in mm)

Product	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i>	<i>Epidermophyton floccosum</i>
Cream 8 (1)	14	50	70	65
Cream 8 (2)	5	15	55	55

The combination Cream 9 (1) was observed to be the best as compared to all the combination prepared.

Example 5

In this experiment the concentration of active ingredients were not changed. The modification was done in the base. The quantity of cetyl alcohol was reduced.

Preparation of cream

Ingredients

Stearyl alcohol	2.0 g.
Cetyl alcohol	1.0 g.
White petrolatum	2.0 g
Propylene glycol	4.2 g.
Garlic extract.	0.3 g
<i>M. spicata</i> (Ganga) oil	0.5 ml
	10 gm.

Stability of the anti dermatophytic activities of the formulation by hole diffusion method (Net zone of inhibition in mm)

Cream 9	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i> *	<i>Epidermophyton floccosum</i> *
Freshly prepared cream	18	28	60*	55*
After 3 months	22	25	66*	50*
After 6 months	12	19	45*	46*
After 12months	13	21	45	45*

* Complete lysis occurs after 5-7 days of incubation.

From the experiments of other non published work it was found that if the quantity of white petrolatum is replaced by propylene glycol the efficacy of the cream is further improved. So the final cream was prepared by adding the appropriate

amount of propylene glycol and instead of using filtrate the extract was centrifuged at 10000 rpm for 10 min at room temperature. The supernatant was used in the preparation of the cream. This modification provided a better texture and smoothness of the cream and also was easily spreadable on the skin surface.

Cream 10	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i> *	<i>Epidermophyton floccosum</i> *
Freshly prepared cream	21	33	73	44
After 3 months	20	30	73	67
After 4 months	21	33	CL	CL

CL. Complete lysis after 5-7 days of incubation.

Example 6:

Comparative evaluation of present formulation with the creams available in market. (Net zone of inhibition in mm)

Formulation	<i>Candida albicans</i>	<i>Trichophyton rubrum</i>	<i>Microsporum gypseum</i>	<i>Epidermophyton floccosum</i>
Candid	20	16	40	20
Ring guard	17	-	33	30
Quadiderm	15	17	27	20
Krack	-	-	18	15
Lichensa	2	-	20	19
Cream 10	22	25	60	50

The cream was subjected to clinical trials on 10 volunteers suffering from superficial fungal infection and all volunteers reported reduction in the infection in three days of application two times a days. After one week of application 8 volunteers reported complete cure.

The cream samples were evaluated for primary skin irritation test in rabbits as per standard protocol of OECD guidelines and in all samples the primary irritation index was calculated to be 0.

Example 7: Garlic as the enhancer of activity of essential oil

The minimum inhibitory concentrations of the essential oils were decreased to several folds in presence of the garlic extract (Propylene glycol) indicating the enhancing and synergistic activity of garlic extract on activity of essential oils.

MIC of Essential oils	Garlic extract	MIC of Essential oils in Combination with garlic extract
1/3200 Clove oil	1/800	1/12800
1/1600 Coriander oil	1/800	1/12800
1/1600 <i>Mentha piperita</i>	1/800	1/25600
1/1600 <i>Eukalyptus globulus</i>	1/800	1/6400
1/1600 <i>Ocimum santum</i>	1/800	1/6400

Example 8: Mechanism of action

The improved preparation (Cream 10) was also tested against isolated resistant mutants of *Candida albicans* against Clotrimazole, Amphotericin B and Nystatin. As most of the available antifungal available in the market contain these compounds the cream of invention /improved formulation was compared with them. Clotrimazole inhibits the biosynthesis of ergosterol in *Candida albicans*. The resistant mutants produce modified enzyme which can not bind to the azole group of compounds. But the compounds which inhibits more to the resistant mutants may be taken as potent inhibitor of ergosterol biosynthesis, which was observed in the improved preparation. Similarly, Amphotericin B and Nystatin resistant mutants were developed in the laboratory and the activity of the improved preparation was tested against a series of mutants showing different degree of resistance. The mutants resistant against Amphotericin B are also resistant against Nystatin. The polyenes binds to ergosterol and make it non-available for cell membrane biosynthesis there by inhibiting the growth. In mutants the sterol can not binds to the polyenes and hence resistance develops. The improved preparation also showed considerable activity against these mutants indicating the reduced availability of ergosterol for membrane. Hence the preparation (Cream 10) inhibit the biosynthesis of ergosterol and also makes it

unavailable for membrane biosynthesis. The result of the experiments conducted as "hole diffusion assay" are provided below. All the activities of the preparation are better than the tested market available preparations and inhibit the growth of the fungus by inhibiting ergosterol biosynthesis and also making the sterol non-available for cell membrane biosynthesis.

Evaluation of improved preparation by hole diffusion method against *Candida albicans* WT and Azole(clotrimazole) resistant mutants(Net zone of inhibition in mm)

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	WT	Clo 31	Clo 128	Clo 39	Clo 29
Lichensa	2 mm	-	-	-	-
Candid	20 mm	8	3	3	5
Ringguard	17 mm	10	10	8	10
Krack	-	-	-	-	-
Cream 10	21 mm	33	23	28	40

Evaluation of improved preparation by hole diffusion method against *Candida albicans* (MTCC 1637) and AmphotericinB resistant mutants (Net zone of inhibition in mm).

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	WT	A1	A10	A15	A17
Lichensa	2 mm	-	3	-	-
Candid	20 mm	8	9	9	5
Ringguard	17 mm	4	8	5	5
Krack	-	-	-	-	-
Cream 10	21 mm	10	16	13	9

Evaluation of improved preparation by hole diffusion method against *Candida albicans* (MTCC 1637) and Nystatin resistant mutants (Net zone of inhibition in mm)

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	Wild type	N7	N8	N16	N30
Lichensa	2 mm	8	7*	-	14*
Candid	20 mm	14	10	11*	11

Ringguard	17 mm	17	11	3	7
Krack	-	-	-	-	-
Cream 10	21 mm	20	20	14	20

*fungistatic zone

Example 7: Garlic as the enhancer of activity of essential oil

The minimum inhibitory concentrations of the essential oils were decreased to several folds in presence of the garlic extract (Propylene glycol) indicating the enhancing and synergistic activity of garlic extract on activity of essential oils.

MIC of Essential oils	Garlic extract	MIC of Essential oils in Combination with garlic extract
1/3200 Clove oil	1/800	1/12800
1/1600 Coriander oil	1/800	1/12800
1/1600 <i>Mentha piperita</i>	1/800	1/25600
1/1600 <i>Eukalyptus globulus</i>	1/800	1/6400
1/1600 <i>Ocimum santum</i>	1/800	1/6400

Example 8: Mechanism of action

The improved preparation (Cream 10) was also tested against isolated resistant mutants of *Candida albicans* against Clotrimazole, Amphotericin B and Nystatin. As most of the available antifungal available in the market contain these compounds the cream of invention /improved formulation was compared with them. Clotrimazole inhibits the biosynthesis of ergosterol in *Candida albicans*. The resistant mutants produce modified enzyme which can not bind to the azole group of compounds. But the compounds which inhibits more to the resistant mutants may be taken as potent inhibitor of ergosterol biosynthesis, which was observed in the improved preparation. Similarly, Amphotericin B and Nystatin resistant mutants were developed in the laboratory and the activity of the improved preparation was tested against a series of mutants showing different degree of resistance. The mutants resistant against Amphotericin B are also resistant against Nystatin. The polyenes binds to ergosterol and make it non-available for cell membrane biosynthesis there by inhibiting the growth. In mutants the sterol can not binds to the polyenes and hence resistance develops. The improved preparation also showed considerable activity against these

mutants indicating the reduced availability of ergosterol for membrane. Hence the preparation (Cream 10) inhibit the biosynthesis of ergosterol and also makes it unavailable for membrane biosynthesis. The result of the experiments conducted as "hole diffusion assay" are provided below. All the activities of the preparation are better than the tested market available preparations and inhibit the growth of the fungus by inhibiting ergosterol biosynthesis and also making the sterol non-available for cell membrane biosynthesis.

Evaluation of improved preparation by hole diffusion method against *Candida albicans* WT and Azole(clotrimazole) resistant mutants(Net zone of inhibition in mm)

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	WT	Clo 31	Clo 128	Clo 39	Clo 29
Lichensa	2 mm	-	-	-	-
Candid	20 mm	8	3	3	5
Ringguard	17 mm	10	10	8	10
Krack	-	-	-	-	-
Cream 10	21 mm	33	23	28	40

Evaluation of improved preparation by hole diffusion method against *Candida albicans* (MTCC 1637) and AmphotericinB resistant mutants (Net zone of inhibition in mm).

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	WT	A1	A10	A15	A17
Lichensa	2 mm	-	3	-	-
Candid	20 mm	8	9	9	5
Ringguard	17 mm	4	8	5	5
Krack	-	-	-	-	-
Cream 10	21 mm	10	16	13	9

Evaluation of improved preparation by hole diffusion method against *Candida albicans* (MTCC 1637) and Nystatin resistant mutants (Net zone of inhibition in mm)

Preparations	<i>Candida albicans</i>	<i>Candida albicans</i> mutants			
	Wild type	N7	N8	N16	N30
Lichensa	2 mm	8	7*	-	14*

Candid	20 mm	14	10	11*	11
Ringguard	17 mm	17	11	3	7
Krack	-	-	-	-	-
Cream 10	21 mm	20	20	14	20

*fungistatic zone

The invention provides a novel formulation based on the synergistic action of garlic extract and essential oil of *M. spicata* var Ganga or cinnamon oil alone or in combination with both which may further be enhanced by menthyl acetate or Geraniol. Further the invention provides a method of preparation of the synergistic combination. The shelf life of the said invention was observed to be more than one year. The oil of *M. spicata* var Ganga act as preservative for the cream. The cream is a potent anti-dermatophytic as described and illustrated and evaluated in human volunteers.